

Fatigue analysis applied to Ocean Structural Systems



Rita Dantas

rdantas@inegi.up.pt

Supervisor(s): José Correia¹, Abílio de Jesus¹, Grzegorz Lesiuk²

¹ INEGI & CONSTRUCT, University of Porto, Porto 4200-465, Portugal;

² Wrocław University of Science and Technology, PL-50370 Wrocław, Poland;

*rdantas@inegi.up.pt

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Background and Motivation

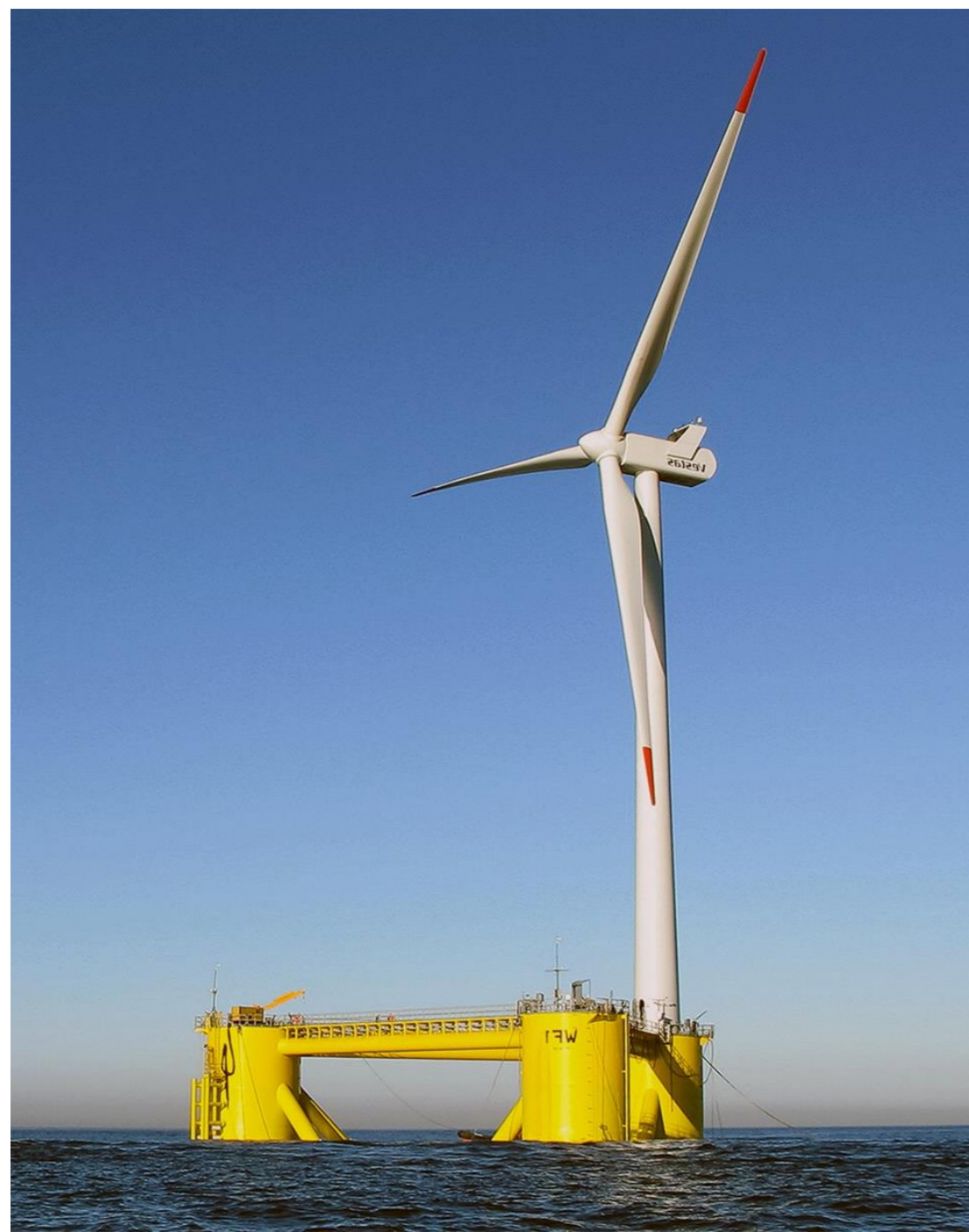


Figure 1. Offshore wind turbine [1]

In 2022, the record emissions and temperature increases witnessed have been an unequivocal warning sign of the global heating. Furthermore, the consumer has been facing a brutal inflation with a considerable increase in fuel and energy prices. Therefore, wind energy can be a green alternative to mitigate these problems. During the last year, offshore wind industry has grown three times more than in 2020 and achieved a global cumulative capacity of 56 GW. In particular, due to geographic characteristics, Portugal is in the top five markets in total floating wind installations (a technology with a tremendous potential) [2].

The fatigue analysis is a key step to assure offshore structural integrity, since the wind and wave cyclic loads can not be neglected [3]. Fatigue life evaluation can be also important to re-power decommissioned oil and gas offshore structures for wind energy generation.

Main Goals

- Evaluate the fatigue damage in a structural steel used in offshore industry (S690 steel), when loaded to a number of cycles beyond the conventional fatigue limit – the gigacycle region;
- Develop a methodology to perform fast fatigue tests through ultrasonic fatigue testing;

Gigacycle Fatigue

Testing beyond 10^6 cycles in a conventional machine is a very time consuming task, so the fatigue limit has been settled around this number of cycles. However, during the service life, structural details can experience a larger number of cycles. Thus, the gigacycle region and the concept of fatigue limit has been matter of study in the last decades [4]. In order to overcome the time effort required, ultrasonic fatigue testing machine has been developed [5]. However, ultrasonic testing introduces new challenges such as the effect of frequency, the overheating due to high testing frequencies, and new mechanisms of failure (internal crack initiation). Moreover, the fatigue specimens need to be designed to have one of the natural frequencies equal to 20 kHz (the working frequency of the ultrasonic fatigue actuator). During this work, a methodology to design a fatigue specimen was developed to carry on ultrasonic fatigue tests in S690 steel.

Material characterization

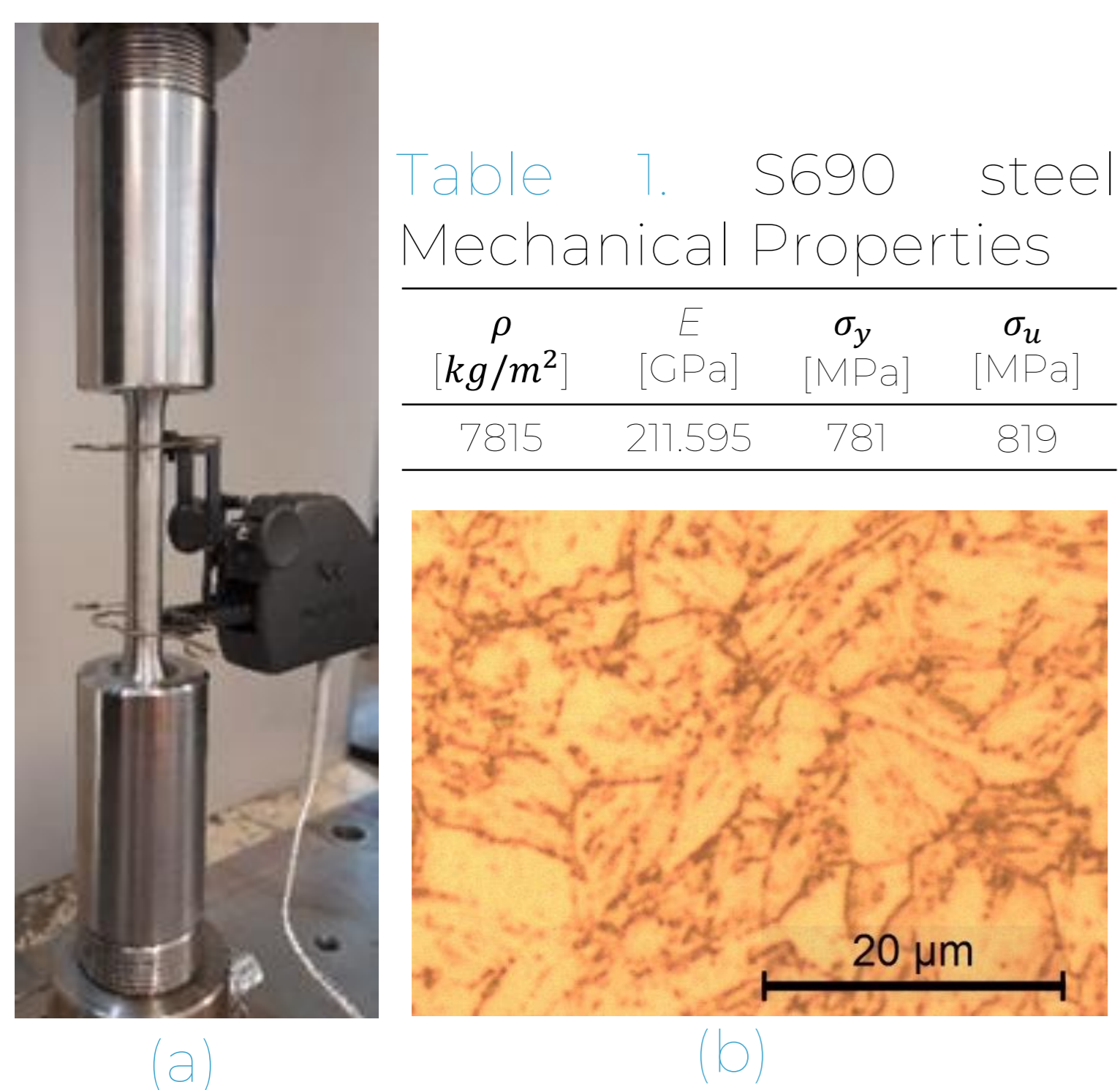


Table 1. S690 steel Mechanical Properties

ρ [kg/m ³]	E [GPa]	σ_y [MPa]	σ_u [MPa]
7815	211.595	781	819

Geometry definition for $f=20$ kHz by numerical or analytical approach

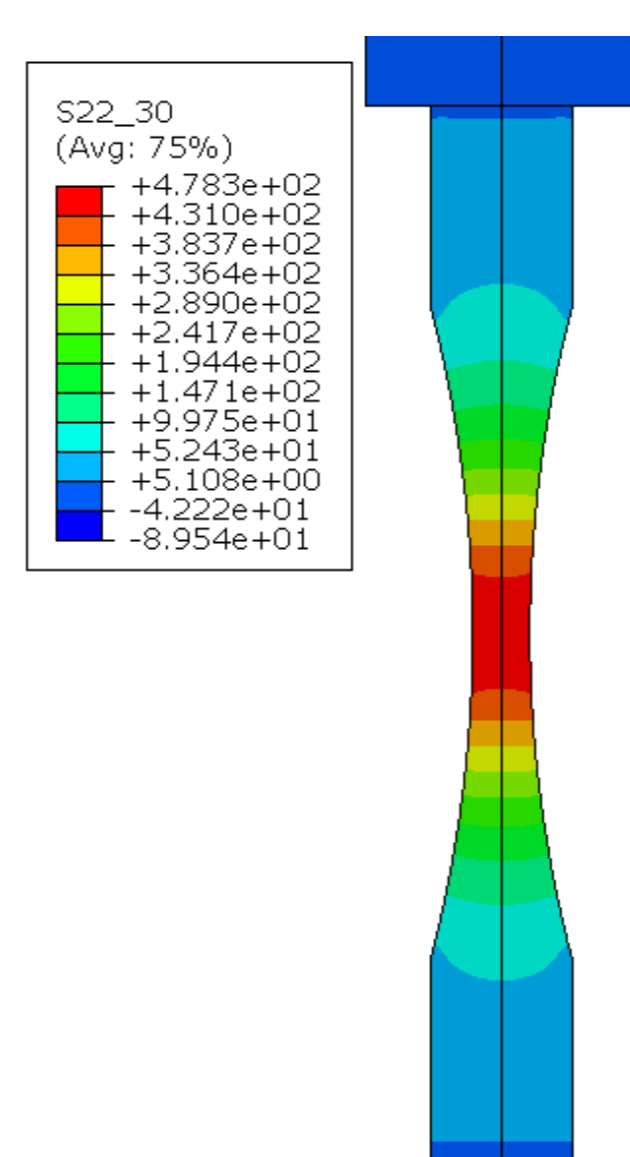


Figure 3. Stress field during the

Ultrasonic Fatigue testing

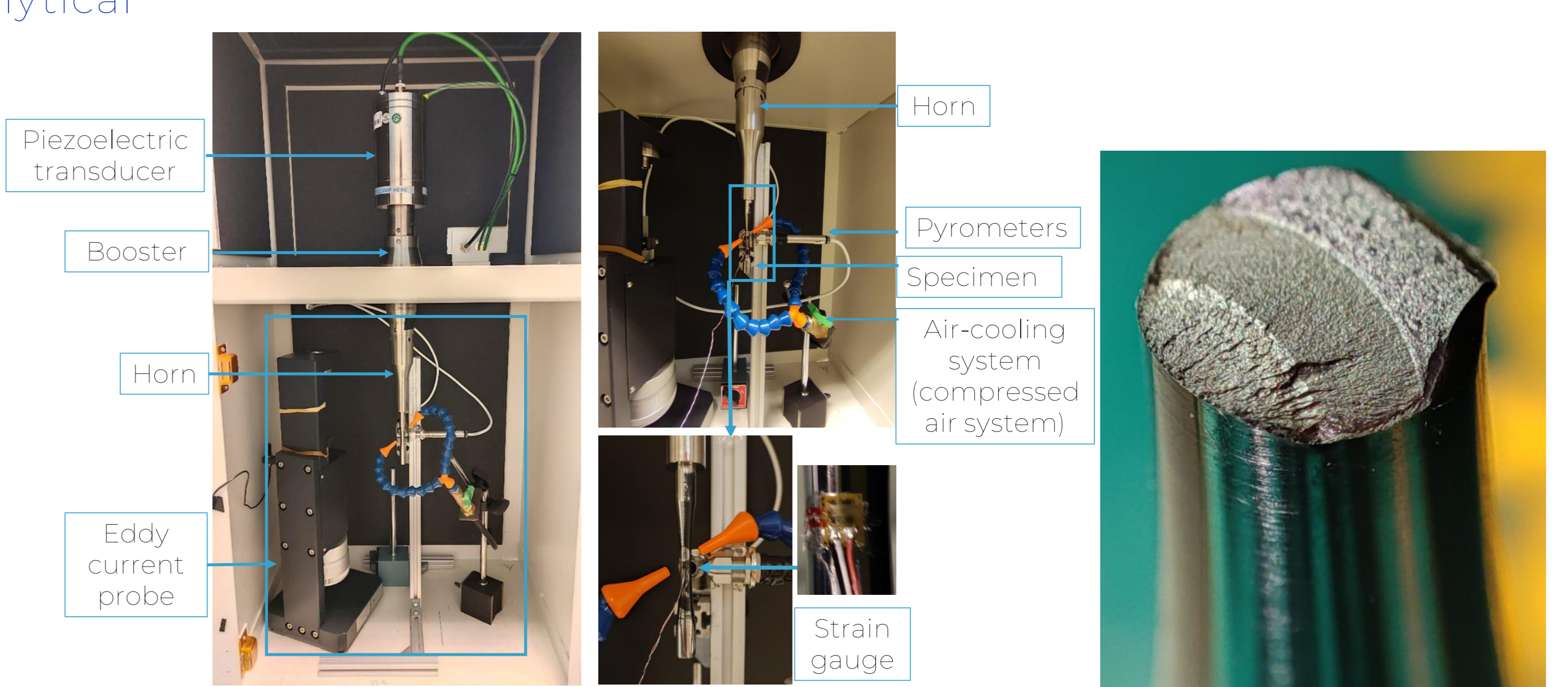


Figure 4. Ultrasonic test system (Shimadzu USF2000) Figure 5. Fracture surface

Acknowledgments

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